

# **Economic Impact of Metrology Programs**

***...a retrospective view***

**Hratch G. Semerjian, Director  
Chemical Science and Technology Laboratory**

**Visiting Committee on Advanced Technology  
March 18, 2003**

# Economic Impact of Metrology

## ***Evaluated through:***

- Stakeholder feedback
- Dissemination of outputs
- Anecdotal information
- Formal impact studies

# Formal Impact Studies

- Independently carried out by economists; based on survey of customers
- One of several methods used to assess impact of our programs
- Used to increase the credibility of anecdotal evidence, and “back of the envelope” calculations of impact

# NIST Formal Impact Studies

<i><b>Industry:</b></i>	<i><b>Project</b></i>	<i><b>SRR</b></i>	<i><b>BCR</b></i>
<i><b>Semiconductors:</b></i>	Resistivity	181%	37
	Thermal conductivity	63%	5
	Wire Bonding	140%	12
	Electromigration	117%	12
	Software for design automation	76%	23
<i><b>Communications:</b></i>	Electromagnetic interference	266%	
	ISDN	156%	
	Data encryption standards	267-272%	58-145
	Role-based access control	44%	109
<i><b>Automation:</b></i>	Real-time control systems	149%	
	Machine tool software error compensation	99%	118
<i><b>Photonics:</b></i>	Optical fiber	423%	
	Spectral irradiance	145%	13
	Optical detection calibration	72%	3
	Laser & fiberoptic power calibrations	43-136%	3-11

*lower transaction costs - lower compliance costs - energy conservation  
increase R&D efficiency - increase product quality - enable new markets*

# NIST Formal Impact Studies (Cont'd)

<i>Industry:</i>	<i>Project</i>	<i>SRR</i>	<i>BCR</i>
<i>Energy:</i>	Electric meter calibration	117%	12
<i>Computers:</i>	Software conformance	41%	
<i>Electronics:</i>	Josephson voltage standard	87%	5
<i>Materials:</i>	<i>Thermocouple calibration</i>	<i>32%</i>	<i>3</i>
	Phase equilibria for advanced ceramics	33%	10
<i>Pharmaceuticals:</i>	Radiopharmaceuticals	138%	97
	<i>Cholesterol</i>	<i>154%</i>	<i>4.5</i>
<i>Chemicals:</i>	<i>Alternative refrigerants</i>	<i>433%</i>	<i>4</i>
	<i>Sulfur in fossil fuel</i>	<i>1,056%</i>	<i>113</i>
	<i>Gas Mixture NTRMs</i>	<i>225%</i>	<i>24</i>
<i>Construction:</i>	Building codes	57%	
	Roofing shingles	90%	
	Fire safety evaluation systems	35%	

<http://www.nist.gov/director/planning/studies.htm>

# CSTL Economic Impact Studies

<i>Title</i>	<i>Product/Output</i>	<i>Outcome</i>	<i>Metrics</i>
<b><i>Gas Mixture NTRMs 2002</i></b>	Reference standards, traceability structure, Certification services	Increased efficiency of regulatory compliance	SRR: 221% BCR: 21 NPV: \$49M
<b><i>Cholesterol Standards Program 2000</i></b>	Pure Cholesterol and serum-based SRMs, and Reference Method	Increased productivity and measurement reliability	SRR: 154% BCR: 4.5 NPV: \$3.5M
<b><i>Sulfur in Fossil Fuel 2000</i></b>	Suite of SRMs: Kerosene, Oil, Coke, Coal, Fly Ash	Increased productivity and reduced transaction costs	SRR: 1056% BCR: 113 NPV: \$409M
<b><i>Alternative Refrigerants Research Program 1998</i></b>	SRD 23 REFPROP Database	Increased R&D efficiency, accelerated innovations and regulatory compliance	SRR: 433% BCR: 4
<b><i>Thermocouple Calibration Program 1997</i></b>	Data and calibrations, traceability structure	Increased product quality, reduced transaction costs	SRR: 32% BCR: 3

SRR: Social Rate of Return

BCR: Benefit-to-cost Ratio

NPV: Net Present Value

# Formal Impact Studies

## *... common threads*

- Well-defined customer set
- Driving force
- Response to industry demand

# Gas Mixture NTRMs

*SO<sub>2</sub> emissions trading increased from around 200 transactions in 1994 to nearly 3000 in 1999 – trading system could save industry as much as \$3B/year*

***Well-defined customer set:*** Specialty gas companies (SGCs)

***Driving force:*** 1990 amendment Clean Air Act required significant increase in pollution monitoring. Market for compliance was too large for demand to be met directly with the NIST Gas Mixture SRMs.

***Response to Industry Demand:*** Established NTRM program in 1992 in collaboration with EPA and SGCs. NTRM gas mixture standards are:

- Commercially produced
- Market driven
- Well-defined traceability linkage to NIST primary standards

Since 1992, **8624** NTRM cylinders have been produced by **15 SGCs**, resulting in the production of **500,000** EPA Protocol Gas Standards, valued at **\$140,000,000**



***Recent Developments:*** In 2004, California will require new automobile fleets to meet LEV II exhaust emission standards that mandate a reduction of NO<sub>x</sub> by a factor of 8, and non-methane organic gas by a third.



# Cholesterol SRMs

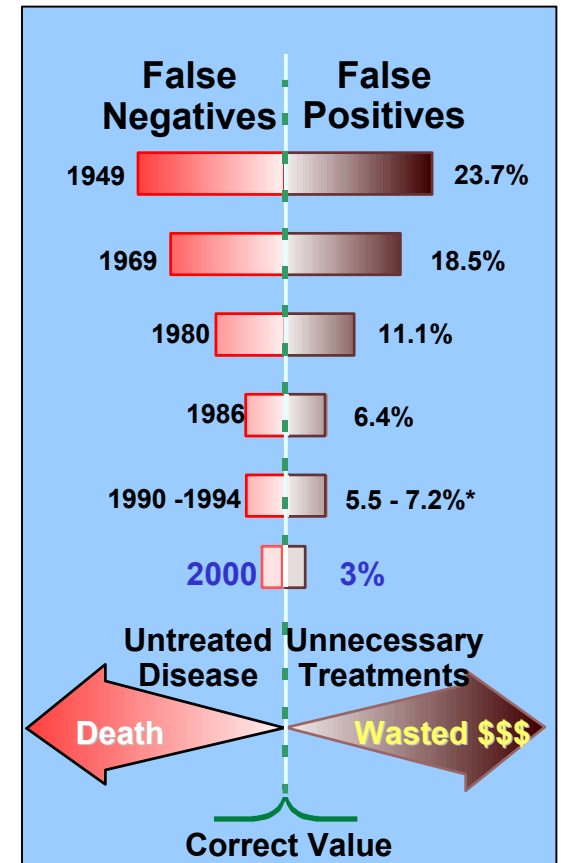
*Measurement improvements may have saved \$100M/year in treatment costs*

**Well-defined customer set:** Manufacturers of test kits and reagents, and network and clinical laboratories

**Driving force:** Early collaborations with AACC, NIH, and FDA to improve clinical measurements of cholesterol. By 1982, CDC developed a PT network for assuring the standardized measurement of cholesterol requiring highly accurate and precise methods as well as SRMs. NIST in collaboration with CAP provides the anchor for PT measurements.

**Response to Industry Demand:** Series of SRMs, beginning with a pure cholesterol standard in 1966, IDMS method developed by 1980, along with human serum standards, and freeze-dried and frozen serum standards in the 1990s.

**Recent Developments:** EU IVD Directive states that by December 2003 all kits sold in EU must be traceable to standards of a higher order. Current US market share in Europe is about 60%.



\* Data from  
GAO/PEMD-95-8

# Sulfur In Fossil Fuel SRMs

*Each year, the US coal industry produces and distributes 1.1 billion short tons of coal and the petroleum industry supplies over 6 billion barrels of petroleum*

***Well-defined customer set:*** Transportation (diesel, gasoline); Energy (Coal); Steel (Coke)

***Driving force:*** 1990 Clean Air Act and subsequent amendments aimed to reduce the amount of sulfur emitted into the environment; custody transfer issues; sulfur content important determinant in value of fossil fuel

***Response to Industry Demand:*** Suite of nearly 30 SRMs that include fossil fuels, kerosene, coal, lubricating base oil, fly ash, gasoline, coke.



***Recent Developments:*** By 2010 all diesel fuel must meet a 15  $\mu\text{g/g}$  cap, putting additional constraints on industry that could translate into higher potential cost avoidance through the use of SRMs. The new diesel fuel SRM has a sulfur concentration of 11  $\mu\text{g/g}$ .

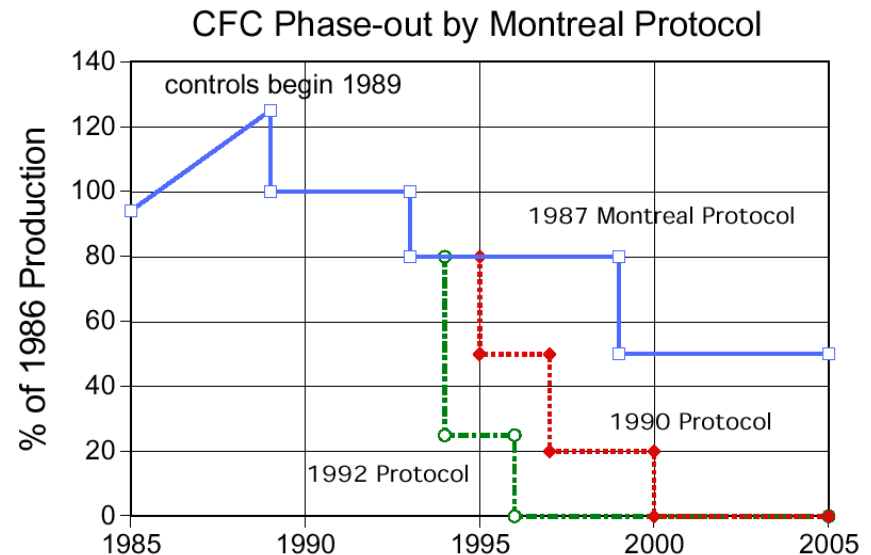
# Alternate Refrigerants Research Program

*CFCs used in \$350B installed equipment, and in processes worth \$28B/year*

**Well-defined customer set:** Refrigerant manufacturers

**Driving force:** *Montreal Protocol* (1987 and revisions) mandated phase-out of CFCs and HCFCs; and *Kyoto Protocol* (1997) regulates HFCs

**Response to Industry Demand:** NIST provided evaluated, publicly available data, *NIST SRD 23 REFPROP*, that allowed individual companies to independently develop new products without IP issues. This database has been key in developing CFC replacements seven years ahead of the original schedule proposed in the 1987 Montreal Protocol.



## **Internationally Adopted**

- IEA Annex 18 – Int'l Standard Equations of State
- ISO Standard 86
- Distributed through ARI, IIR, ASHRAE, etc.

# Thermocouple Calibration Program

*World temperature sensor market sales about \$5 billion*

***Well defined customer set:*** Scope limited to wire suppliers and thermocouple producers. ***No attempt was made to survey the broad and diffuse user community*** (medical, automotive, chemical, food, pharmaceutical, aerospace, oil, utilities, glass, plastics)

***Driving force:*** Accuracy and traceability requirements for trade and commerce

***Response to Industry Demand:*** NIST provides data and calibration services, and does research to improve the accuracy and precision of temperature metrology and the International Temperature Scale (ITS).

***The ITS (from 1927 to present) support and promote industrial innovations.***

***Recent Developments:*** The new definition of the ITS-90 enabled the determination at NIST of highly accurate reference functions for pure element thermocouples, such as gold versus platinum and platinum versus palladium, leading to commercialization and adoption by industry.



# Demonstrating Value to the Nation

## *Economic Impact Studies help:*

- Quantify impact of programs
- Demonstrate relevance
- Articulate customer focus
- Program planning (lessons learned)

## *Economic Impact Studies affect:*

- Relationship with stakeholders
- Assessment process
- Staff visibility
- Customer relations